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Structural Change on Ohio Farms

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Abstract

Future farm size distribution is projected for Ohio farms using Markov chain analysis. Transition matrices used to estimate farm structure are based on changes in gross farm sales and acres farmed between 1986 and 1988. When gross sales is used as a measure of size, growth is projected in the percent of farms in sales categories larger than $100,000. Concurrently, there is a decrease in the percent of farms in the sales categories less than $100,000. Projected farm size distributions based on acres farmed show only slight changes from actual 1988 farm size distributions.

Ordinary least squares regression is used to determine those factors influencing changes in farm size and profitability. Results indicate that changes in farm size, as measured by percent change in gross sales, are positively influenced by farm size and farms' enterprise mix. Profitability, as measured by percent return on assets, is positively influenced by farm size and negatively by age.

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In the early 1980's, reduced exports, high interest rates, and falling farmland prices caused changes throughout the U.S. farming sector and resulted in lower incomes, farm foreclosures, and changes in farm structure. Farms appeared to be evolving toward either larger farms able to realize greater economies of size in production and marketing or the smaller part-time farms receiving a majority of income from non-farm sources (Tweeten).

Studies of farm structure been mixed in forecasting future farm size distribution in the United States. Scenarios range from those showing a movement towards a bimodal distribution of many small farms and an increasing proportion of large farms (U.S. Congress) to scenarios forecasting stability with little change in the farm size distribution (Edwards et al.). Garcia et al. stated that recent studies of farm size distribution are difficult to compare because of differences in models, time periods, and size measures used in empirical analysis. In addition, they also point to the fact that there is a lack of micro-level evidence to corroborate findings based on aggregate agricultural census data.

Government policies, technology, market conditions, and off-farm income are factors most cited in the literature as influencing farm structure (Tweeten). Studies of farm structure utilizing micro-level data suggest that farm size is closely associated with returns to management, management intensity, and government program participation (Garcia et al.). Other studies indicate that farm growth is positively influenced by family size and managerial ability and negatively influenced by off-farm income (Upton and Haworth). These studies have yielded valuable insights into the factors influencing the size and growth of the farm firm. However, many may have inaccurately represented the farm sector because they excluded operators deriving a substantial portion of their income from off-farm sources.

In this study we use data from the Ohio Farm Longitudinal Survey to measure recent changes in farm size distribution of a representative sample of Ohio farms and use this information to project farm size distribution in 1990 and 2000. In addition, we evaluate the influences of selected farm and farm operator characteristics on changes in farm size and farm profitability.

The Data Set

The data set used in this study is a subset of the data from the Ohio Farm Longitudinal Survey conducted by The Ohio State University in 1986, 1987, and 1988. Data were collected from 937 farm households in 1986, 891 farm households in 1987, and 922 households in 1988.

Longitudinal studies are designed to examine change over time. The sample in this study is designed to be representative of the farm operator population. After the first year, the sample consists of those farm households participating in the previous year plus replacements for those dropping out of the study or those being systematically replaced. Replacement over time is necessary to assure representativeness of the sample.

Farm operators in the sample were selected randomly from the population of Ohio farm operators and fully depict the range of conditions existing on Ohio farms. Of the 937 households in the 1986 sample, 675 participated in 1987 and another 216 were chosen randomly to add to the sample. In the 1988 sample, approximately 20 percent of the previous year's participants again were replaced with randomly selected households. In both 1987 and 1988, replacement operators' gross sales were not significantly different than the gross sales of those dropping out of the sample.

The 467 farm households used for this analysis participated in the study during all three years. Farm households were surveyed for demographics, off farm employment, financial, production and marketing data. Table 1 presents a summary of selected financial, production and demographic information of the farm households in the data set. All financial variables were deflated by the producer price index of Ohio farmers and using 1986 as a reference year. The variables used in our analysis of changes in farm size are explained later in more detail.

Projections of Farm Size Distributions

Markov chain analysis was performed using the method reported in Edwards et al. and Garcia et al. Deflated gross farm sales and acres farmed are used as measures of size. Both measures of size are used because of the inherent limitations that each has in capturing farm size. The use of gross sales accurately measures farm size when a farm sector has high enterprise diversity. If farm firms have similar enterprises and technology then acres farmed will be a good measure of size. Deflated gross farm sales included receipts from crops, livestock, custom work, and government farm programs, as well as changes in the value of inventories. Gross farm sales were deflated by the producer price index of Ohio farmers and using 1986 as a reference year (Table 2) .

Gross farm sales and acres operated were classified into 13 and 10 categories, respectively (Tables 3 and 4). Transition matrices are calculated using the data collected in 1986 and 1988 and then used to project farm size distributions in 1990 and 2000. These estimates are presented in Tables 3 and 4. While Markov analysis using data measured over a narrow period of time has some inherent limitations, we feel that it may offer some useful insights into future trends of farm size distribution in Ohio. The 1986-1988 period was period of consolidation after the economic debacle of the early 1980's. Extrapolating changes occurring during 1986-88 provides a more accurate projection of future structural change than would extrapolations based on a longer time series in the tumultuous 1980's.

Projections of farm size distribution are different with respect to the measure of size used in the analysis. In terms of gross farm sales, growth in the percent of farms in sales categories larger than $100,000 is projected with the largest growth occurring in the $250,000-$400,000 sales classes (Table 3). If farm size is measured by gross sales, our analysis suggests a shift in the size distribution toward larger farms. The projected structural shifts of farm size distribution are similar to that reported utilizing aggregate level census data (see Edwards et al.). However, our results indicate lower growth in the largest sales classes and smaller decreases in the smallest sales classes than reported elsewhere. One explanation for this may be the fact that many of the studies using aggregate level census data measured structural changes in the 1970's - a time of rapid structural change. The projected change in farm structure in our study is based on a relatively stable farm economy in the 1986-88 period.

A somewhat different picture of farm growth emerges when acres operated is used as a measure of size (Table 4). The projections indicate little change in farm size distribution. Moderate growth is projected in the proportion of farms in the less than 200 acre size categories. The percent of farms operating more than 1200 acres is projected to decline slightly. The growth in the number of farms with less than 200 acres may be the result of more part time farmers with a high proportion of non-farm income purchasing land (Tweeten). In addition, technology changes in the farm sector may allow one who has substantial non-farm income to farm more acres with the same amount of labor.

Factors Affecting Changes in Farm Size and Profitability

To account for the changes in the farming sector we evaluated several variables that we believe influence farm growth and profitability. These are a) size of farm, b) participation in government programs, c) financial risk, d) enterprise mix, e) off-farm income, f) age of operators, g) education of operator, h) use of information (e.g., consultants and/or computers), and i) the number of farm enterprises.

Gross farm income is calculated by adding up all the farm receipts and adjusting for inventory changes. In the first equation, the dependent variable, change in farm size is measured as the percent change in gross farm income from 1986 to 1988 (GROSS SALES CHANGE). A better measure of the economic performance of the farm operation is the rate of return on farm assets. It is computed by subtracting a charge for unpaid labor and management from net farm income, adding interest paid, and dividing the result by the value of the farm assets. The rate of return on assets measures returns to a single resource rather than a basket of capital and labor resources. In the second equation, the dependent variable is the percent return to assets averaged over all three years of the study (PROFIT).

In both equations, the independent variables are characteristics of the farm household and farm operator, and for each farm household the independent variables are measured as mean values for the three years of this study. All monetary variables are deflated using prices paid to producers in Ohio and using 1986 as a base year

(Table 2). Both models were tested for heteroscedasticity and multicollinearity. Plotted residuals from both models suggest little heteroscedasticity. Correlation analysis of the independent variables indicated that most of the correlations were insignificant. Thus multicollinearity does not appear to be a problem in this study.

Farm size is included as an independent variable because expansion often is motivated by the desire to take advantage of economies of size and to reduce per unit costs by increasing output. Gross farm sales (GROSS SALES) include crop and livestock sales, custom work receipts, government grain program payments, and the change in the value of inventories. In addition to gross sales, the squared term of gross sales (GROSS SALES ^{2}) is included to account for the fact that change in farm size and profitability may increase as gross sales increases but at a decreasing rate.

Government payments as a percentage of gross farm sales (GOVERNMENT PAYMENTS) is used as a proxy for participation in government programs. Numerous investigations have cited government programs as a major factor in the growth of farms. Gardner and Pope suggest that government policies reduce risk by truncating the lower tail of the probability of returns. This may act as an incentive for growth. Correspondingly, the increase in set aside acres that accompany government programs gives management the incentive to expand or more intensively manage a given parcel of land (Garcia et al.); the result being that participation in government programs will have a positive effect on gross sales change and profit.

Growth in gross farm output and profit are often accompanied by increased financial leverage. This may be due to technological change (Shepard and Collins) or personality characteristics such as motivation, ambition, and willingness to accept risk (Upton and Haworth). Upton and Haworth found that farm size and growth are positively associated with an increased propensity to invest. While increased financial leverage may be positively associated with growth in farm size, its effect on profitability may be ambiguous. The effect of debt on profitability will be positive if it finances enterprises in which the added revenue more than offsets the cost of debt. Analogously, the effect of debt will be negative if it finances enterprises that do not yield sufficient revenue. The measure used as an indicator of financial leverage is the debt to asset ratio (DEBT/ASSET RATIO).

To account for differences in farm enterprise mix, livestock sales as a proportion of gross farm sales (LIVESTOCK SALES) is included as one of the variables in our investigation. During 1986-88, livestock prices were relatively high compared to crop prices, and it is hypothesized that both percent change in gross farm sales and profitability might be positively influenced by farms' livestock production.

The increasing importance of off-farm employment is well documented. The percentage of farm operators working off the farm has increased from 39% in 1949 to 54% in 1982 (Gould and Saupe). Upton and Haworth found that the proportion of income from non-farm sources was negatively correlated to various measures of farm size and farm growth. Household members allocate time among a variety of activities - off-farm employment, farm enterprises, household duties, community activities, and leisure. As the commitment to off-farm employment increases, less time is allocated to the farm business. Farm business growth and farm profitability may be dampened as a result. Thus, it may be hypothesized that higher total off-farm income translates to a relatively lower percent change in gross farm sales and average profit. Total off farm income (TOTAL OFF FARM INCOME) is defined as all income in the farm household rising from non-farm sources including wages, salaries, retirement income, interest and dividend earnings, and so forth.

The growth in the size of the farm unit and profitability may be influenced by the age of the operator. Personality characteristics such as motivation and willingness to accept risk change over the operator's lifetime and may contribute to a life cycle of growth and decline of the farm business (Nalson). Also, younger operators are much more likely to adopt new technology and management practices than older operators (Asplund et al.; Patrick et al.). Thus, it would be expected that percent change in gross sales and profit decrease as farmers approach retirement. Age (AGE) is defined as the age of the primary decision maker in the farm household.

The number of years of education possessed by the farm operator may positively influence farm growth and profitability because of more acquired skills possessed by the operator. In addition, operators with more education adopt production innovations earlier than less educated producers (Asplund et al.; Rogers et al.). As has been previously mentioned, the willingness to adopt new products, methods, and innovations is often associated with farm operations having higher growth and profitability. In our study we classified education into four groups modeled as three dummy variables (EDUCATION1, EDUCATION2, and EDUCATION3).

As a farm becomes larger, the operator tends to use more information or hires management expertise. Often this information comes from outside sources via consultants or through the use of computers. Farmers who seek greater amounts of information from numerous sources are more likely to adopt innovations (Feder and Slade; Asplund et al.). As a result farm financial measures such as percent change in gross sales and profit will increase with the use information acquired through computers and consultants. In our study, a dummy variable (COMPUTERS/CONSULTANTS) is used to model the use of computers or consultants.

Risk in a farming operation may be reduced through enterprise diversification. Such diversification may reduce variability in net farm income, but it also may reduce expected net income (Tweeten). It is also likely to moderate changes in gross sales. In our study, the number of farm enterprises present on each farming unit measures diversity and is represented by three dummy variables (ENTERPRISE1, ENTERPRISE2, AND ENTERPRISE3).

The results of ordinary least squares regression analyses are presented in Table 5. Strong positive relationships exist between percent change in gross farm sales and size of farm and enterprise mix. The change in gross sales is negatively influenced by operators using computers or consultants. Relationships between the change in gross farm sales and other explanatory variables are not statistically significant.

Gross sales increased at a greater rate on large farms than they did on small farms. However, the negative coefficient for GROSS $SALES^2$ suggests that modest sized farms had larger percentage increases in gross sales than did larger farm operations, which is consistent with the results of the Markov analysis. The influence of enterprise mix on the change in gross farm sales may be attributed to relatively high 1986-88 livestock prices. Table 2 shows the indexes of prices received by Ohio farmers during the 1986-88 period. During this period, livestock enterprises positively enhanced growth. The unexpected negative relationship between growth and computer/consultant use may be due to the fact that those aggressively expanding are not early adopters of computer technology.

The regression of profit on the selected variables indicates that gross sales and age significantly influenced profit. As expected, farm operations with larger gross farm sales had a higher percent return on assets and vice versa. This result agrees with the fact that larger farms have a strong competitive advantage due to economies of size. Age negatively influenced profitability suggesting that younger operators had higher profitability. This result does not support the hypothesis that older operators are likely to have higher profits because of acquired skills and experience. It does, however, support the notion that younger operators are likely to have higher profits because of faster adoption of new innovations.

The explanatory power of the estimated equations is modest. R^2 for the percent changes in gross sales equation is 0.11 and 0.21 for the profit equation. However, this level of explanatory power is typical of microunit analyses of farm performance.

Summary and Implications

In this paper, current and future farm size and distributions are estimated for a sample of Ohio farms using Markov chain analysis. Projections of farm structure and distribution suggest that the percent of farms in sales categories larger than $250,000 will increase from 5.5 percent in 1988 to 13.4 percent in 2000. Concurrently, the percent of farms in the sales categories less than $100,000, will decrease from 81.5 percent in 1988 to 73.2 percent in 2000. Projected changes in farm size distribution are less marked when acres is used a measure of size than when using gross sales. Our analysis indicates that percent change in gross farm sales between 1986 and 1988 was positively influenced by farm size and livestock sales, and negatively associated with the use of computers/consultants. Profitability was positively influenced by farm size and negatively by age.

Our analysis suggests that the structure of farming will continue to evolve toward larger farms. However, part-time farmers will remain important in the future. By the year 2000, over one-half of Ohio farm households will continue to generate less than $40,000 gross farm sales annually. These farm households will earn most of their household income from off-farm sources and earn relatively low returns to resources committed to agriculture. Commercial farms operations' growth will be characterized by moderately large farms ($150,000 to $250,000 in gross sales) moving into larger sales classes. Rates of return to farm assets are significantly higher among these larger farms and younger, more aggressive operators will continue to consolidate farms.

Kislev and Peterson (1982) argue that relative factor prices are important determinants of farm structure. That is, labor has been relatively expensive in the past half century. Capital substitution for labor has been encouraged, and the development of labor saving technology has been induced. So over course of the last half century, farm businesses' capital base, acreage, and gross sales have expanded.

Economic agents (farmers) respond to changes in relative factor prices in different ways. These agents are not economic robots, instantaneously reacting to changes to relative prices. Their ability and inclination to respond are affected by business and personal characteristics. Our analysis sheds light on the effects of these characteristics on changes in farm structure.

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Table 1. Characteristics of Farms in Sample.

Variable Name	Variable Definition	Mean	Standard Deviation
Continuous Variables			
GROSS SALES CHANGE	Change in gross farm sales from 1986 to 1988 (% increase over 1986)	13.5	162.0
PROFIT	Average return on assets in 1986, 1987 and 1988 (%)	0.708	11.40
GROSS SALES	Gross farm sales ($)	107,000	141,000
GOVERNMENT PAYMENTS	Receipts from government farm programs (proportion of gross farm sales)	0.110	0.159
DEBT/ASSET RATIO	Debt to asset ratio	0.206	0.249
LIVESTOCK SALES	Receipts from livestock sales (proportion of farm sales)	0.430	0.692
TOTAL OFF FARM INCOME	Total off-farm income ($)	36,600	20,200
AGE	Age of operator (years)	50.00	13.00
0-1 Dummy Variables			
EDUCATION1	Education of operator (less than 12 years)	0.102	
EDUCATION2	Education of operator (13 to 16 years)	0.258	
EDUCATION3	Education of operator (more than 16 years)	0.057	
COMPUTERS/ CONSULTANTS	Operators who used consultant or computers	0.470	
ENTERPRISE1	Number of enterprises (2 or 3)	0.315	
ENTERPRISE2	Number of enterprises (4 of 5)	0.252	
ENTERPRISE3	Number of enterprises (more than 6)	0.339	

Table 2. Indexes of Prices Received by Farmers in Ohio for the 1986-1988 Period.

Year	Crops	Livestock	Producer Price Index
	---- 1977=100------		1982=100
1986	92	129	104
1987	88	133	105
1988	119	130	108

Taken from Ohio Agriculture Statistics, 1987, 1988, p. 52.

Table 3. Actual (1986 and 1988) and Projected (1990 and 2000) Size Distributions for a Sample of Ohio Farms: Deflated Gross Value of Farm Sales per Household.

Gross Value of Farm Sales (thousands of dollars)	Year 1986	1988	1990	2000
	--percent distribution-- by class			
<10	31.90	31.30	30.50	27.20
10-20	15.00	15.00	14.60	13.10
20-40	16.00	14.30	13.80	12.80
40-100	20.20	20.90	20.90	20.10
100-150	6.40	7.12	7.29	7.47
150-200	4.16	2.97	2.88	3.01
200-250	3.05	2.86	2.64	2.88
250-300	1.03	2.37	2.77	3.12
300-350	1.17	1.39	1.56	1.92
350-400	0.28	0.77	1.40	5.60
400-450	0.21	0.08	0.09	0.13
450-500	0.21	0.06	0.12	0.26
>500	0.50	1.07	1.58	2.39
Total	100.00	100.00	100.00	100.00

Table 4. Actual (1986 and 1988) and Projected (1990 and 2000) Size Distributions for a Sample of Ohio Farms: Acres Farmed.

Acre Size	Year 1986	1988	1990	2000
	--percent distribution-- by class			
<50	7.19	7.39	7.45	7.53
51-100	10.47	10.47	10.50	10.84
101-200	22.79	23.61	24.28	26.52
201-400	22.79	21.56	21.00	20.58
401-600	12.73	13.76	14.32	14.95
601-800	6.57	6.78	6.83	6.66
801-1000	4.72	4.31	4.27	3.88
1001-1200	2.46	4.11	4.22	3.83
1201-1400	3.29	1.44	1.00	0.78
>1401	6.98	6.57	6.13	4.42
Total	100.00	100.00	100.00	100.00

Table 5. Results of Regression Analysis of Selected Variables on Percent Change of Gross Sales and Average Profit.[#]

Variable	OLS (GROSS SALES CHANGE) Coefficient	t-Statistic	OLS (PROFIT) Coefficient	t-Statistic
INTERCEPT	-0.209	-0.406	-0.019	-0.622
GROSS SALES	6.742E-6	5.316*	8.091E-7	7.355*
GROSS SALES^2	-1.117E-11	-3.942*	-8.482E-13	-4.019*
GOVERNMENT PAYMENTS	0.461	0.925	0.036	1.282
DEBT/ASSET	-0.436	-1.281	-0.021	-1.029
LIVESTOCK SALES	0.243	2.217*	9.067E-4	0.142
TOTAL OFF FARM INCOME	5.177E-6	1.357	3.573E-8	0.149
AGE	-0.007	-1.098	-8.091E-4	-1.926*
EDUCATION1	-0.318	-1.239	0.011	0.672
EDUCATION2	-0.035	-0.203	4.713E-5	0.004
EDUCATION3	0.382	1.141	0.008	0.394
COMPUTERS/CONSULTANTS	-0.316	-1.985*	-0.003	-0.369
ENTERPRISE1	0.121	0.416	0.009	0.538
ENTERPRISE2	0.425	1.413	0.022	1.216
ENTERPRISE3	0.289	0.937	-0.005	-0.264
R^2		0.109		0.208
Adjusted R^2		0.082		0.183
Model F Test		3.939		8.501
		n = 467		n = 464

[#] Performed on Statistical Analysis System (SAS)

* Indicated coefficient significantly different than 0 at $P < 0.10$